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Hydraulic Processes Analysis System (HyPAS)

by Thad C. Pratt and Daryl S. Cook

PURPOSE: This Coastal Engineering Technical Note (CETN) describes a PC-Windows-based system for analyzing, visualizing, and archiving hydrodynamic and related field data taken at inlets and related estuarine and coastal waters. The Hydraulic Processes Analysis System (HyPAS) is also applicable to riverine and laboratory application.

BACKGROUND: Modern electronic instrumentation produces large amounts of data. Often, this abundance of data is not fully utilized because the engineer or scientist does not have an effective way to visualize and analyze it within project time schedule. This problem can be minimized by a set of tools that provides ready capability to visualize, analyze, reduce, and efficiently plot data obtained from such instrumentation. Additionally, such a tool can take advantage of geographically referenced data of high spatial accuracy.

HyPAS is designed to be a Geographic Information System (GIS) for hydraulic information. GIS, a computer system capable of managing, storing, manipulating, and displaying geographically referenced data, is the logical solution to such a problem, in particular considering the combination of spatial accuracy needs and database management needs. A mapping system alone lacks database management capabilities. A spreadsheet or database management system contains little or no accurate mapping capabilities. GIS software provides both applications with a robust set of tools capable of manipulating large amounts of data with high spatial accuracy; typically, however, a substantial learning investment is required to become proficient with GIS software.

HyPAS builds on the inherent power of GIS while supplying easier tools for facilitation of hydraulic process analysis and reducing learning time typical with GIS implementation. HyPAS is an extension to ArcView, a commercially available software package marketed by Environmental Systems Research Institute (ESRI), and requires an additional extension from ESRI, Spatial Analyst. HyPAS was designed for the non-GIS expert with ease of use as a priority. A detailed presentation of instructions for using HyPAS can be found in the HyPAS User's Manual (Pratt and Cook 1999).

HyPAS was developed in support of the U.S. Army Corps of Engineers (USACE) projects. Previous to HyPAS, the delivery of high-resolution survey data could consist of thousands of hard-copy plots. HyPAS was developed to provide analysis tools together with the data, enabling USACE field offices to perform further analysis without numerous and costly, unnecessary plots. Intensive application in the Coastal Inlets Research Program (CIRP), suggestions from USACE District staff, and experience in a wide variety of applied projects has led to the development of a highly effective HyPAS toolbox. These tools have the capabilities for analysis and visualization suited to the particular applications of USACE Districts and their contractors.

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14. ABSTRACT

This Coastal Engineering Technical Note (CETN) describes a PC-Windows-based system for analyzing, visualizing, and archiving hydrodynamic and related field data taken at inlets and related estuarine and coastal waters. The Hydraulic Processes Analysis System (HyPAS) is also applicable to riverine and laboratory application.

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The HyPAS was designed to perform all major functions after collection of data to report writing. The system supports hydraulic and hydrodynamic studies involving:

- Velocity
  - Plan View Contours
  - Plan View Vector Plots
  - Cross-Section Plots

- Sediment Samples
  - Grain-Size Distribution Plots
    - Frequency Weight Histogram
    - Cumulative Frequency Weight Percent
  - Composite Sample From Multiple Samples
  - Comparing Composites with Reference Curves
    - Adjust Fill Factor (R_A)
    - Renourishment Factor (R_J)

- Project Management
  - Importing Photographs
  - Time Series Data Analysis

- New tools are constantly under development to meet project needs.

HyPAS's velocity analysis tools cover three basic applications: contouring an area in plan view from a user-defined constituent and depth range, generating cross sections from a transect, and plotting vector magnitude and direction in plan view from a user-specified depth range. HyPAS's soil sample analysis tools allow the user to generate frequency weight plots, calculate composite sample plots, and perform varied analysis routines. HyPAS's project management tools allow the user to import photographs for project enhancement and import time series data to manage and plot.

GENERATING PLAN VIEW CONTOURS: HyPAS provides the capability of generating contours in plan view for the different constituents collected from the Acoustic Doppler Current Profiler (ADCP) instrument. HyPAS will create color-shaded contours and contour lines.

This tool allows the user to calculate the depth average of the specific values from the entire water column or a specific depth range. The user selects the survey data to contour by drawing a box or polygon around them. A depth range is specified, and the user must choose which constituent to contour. HyPAS then calculates the contour from the depth range specified.

An example plan view contour of total velocity magnitude was created from ADCP data in the Columbia River, Oregon (Figure 1). The yellow dots represent actual velocity profiles collected by the ADCP as the boat moves along the line. The legend for the color-shaded contours

represents velocity magnitude in ft/sec.[1] The units for velocity magnitude depend on how the data were processed. Often, velocity magnitude is represented in cm/sec.

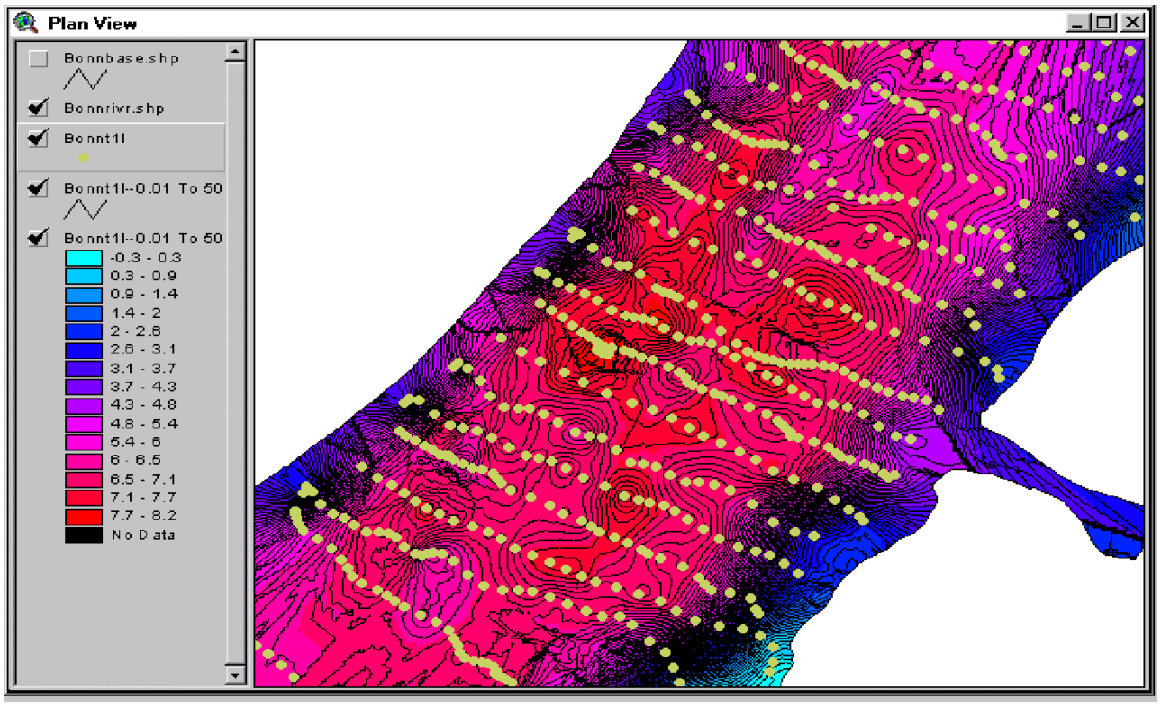

Figure 1. Plan view contour of the total velocity magnitude from an ADCP survey in the Columbia River

GENERATING PLAN VIEW VECTORS: HyPAS provides the capability of generating a vector plot of magnitude and direction in plan view for the velocity data collected from the Acoustic Doppler Current Profiler (ADCP) instrument. HyPAS will create a plot with vectors pointing in the direction of flow and scaled in size by magnitude.

This tool allows the user to calculate the depth average of velocity magnitude and direction from the entire water column or from a specific depth range. The user selects the survey data points to plot by drawing a polygon around them. A depth range is specified. HyPAS then calculates and plots the depth-averaged magnitude and direction for those survey points. Figure 2 is an example of depth-averaged velocity magnitude and direction vectors from ADCP data at Shinnecock Inlet, NY.

[1] To obtain m/sec, multiply by 0.0348.

Figure 2. Plan view velocity magnitude and direction plot from Shinnecock Inlet, NY (flood current)

GENERATING CROSS SECTIONS: HyPAS provides the capability of generating a cross section from a specific transect or points along multiple transects from velocity survey data. This tool allows the user to calculate a cross section from any constituent in the data. This includes the north, east, and vertical components of velocity as well as acoustic backscatter.

The user selects the survey data points by drawing a polygon around the individual points and selecting a starting point. The constituent to contour is selected. HyPAS then interpolates and plots the cross section. A cross section was created from ADCP data collected from an area called Victoria Bend in the Mississippi River (Figure 3).

IMPORTING AND DISPLAYING IMAGES: HyPAS provides the capability of importing and displaying digital photographs and images to enhance project management. This tool is not designed for image processing, but rather as an end product aid for representing analysis results and methods.

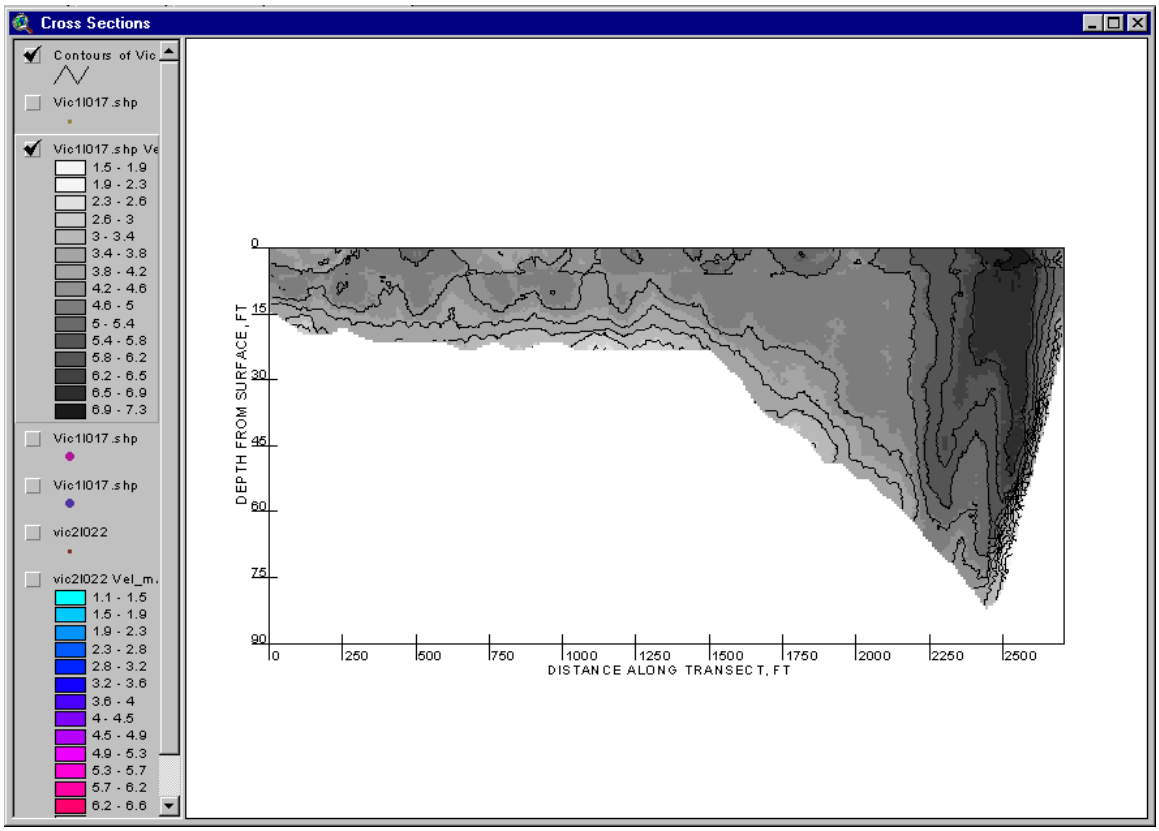

Figure 3. Cross section of Victoria Bend in the Mississippi River

This tool allows the user to import digital photographs and images and attach them to specific spatial locations throughout the study area. The images are stored using a separate image theme as shown in Figure 4. On the image theme, a small solid filled circle with an "i" denotes the locations of the images. Presently, a maximum of 10 digital images can be stored at each spatial location. This tool is useful for recording conditions at a site or progress of a construction site. Images allow the user the opportunity to store and display instruments, flow conditions, historic photos, and other visual information quickly and easily for reference.

Once the user has imported the photography, it is displayed by clicking on the spatial location to which it was linked. Several photographs were added to a GIS project for Shinnecock Inlet, NY. Two photographs are displayed showing the inlet at previous times in its history (Figure 4).

TIME SERIES ANALYSIS: HyPAS provides capabilities for importing, storing, analyzing, and exporting time-series data. This is a project management tool that allows the user to have time-series data flags throughout his project.

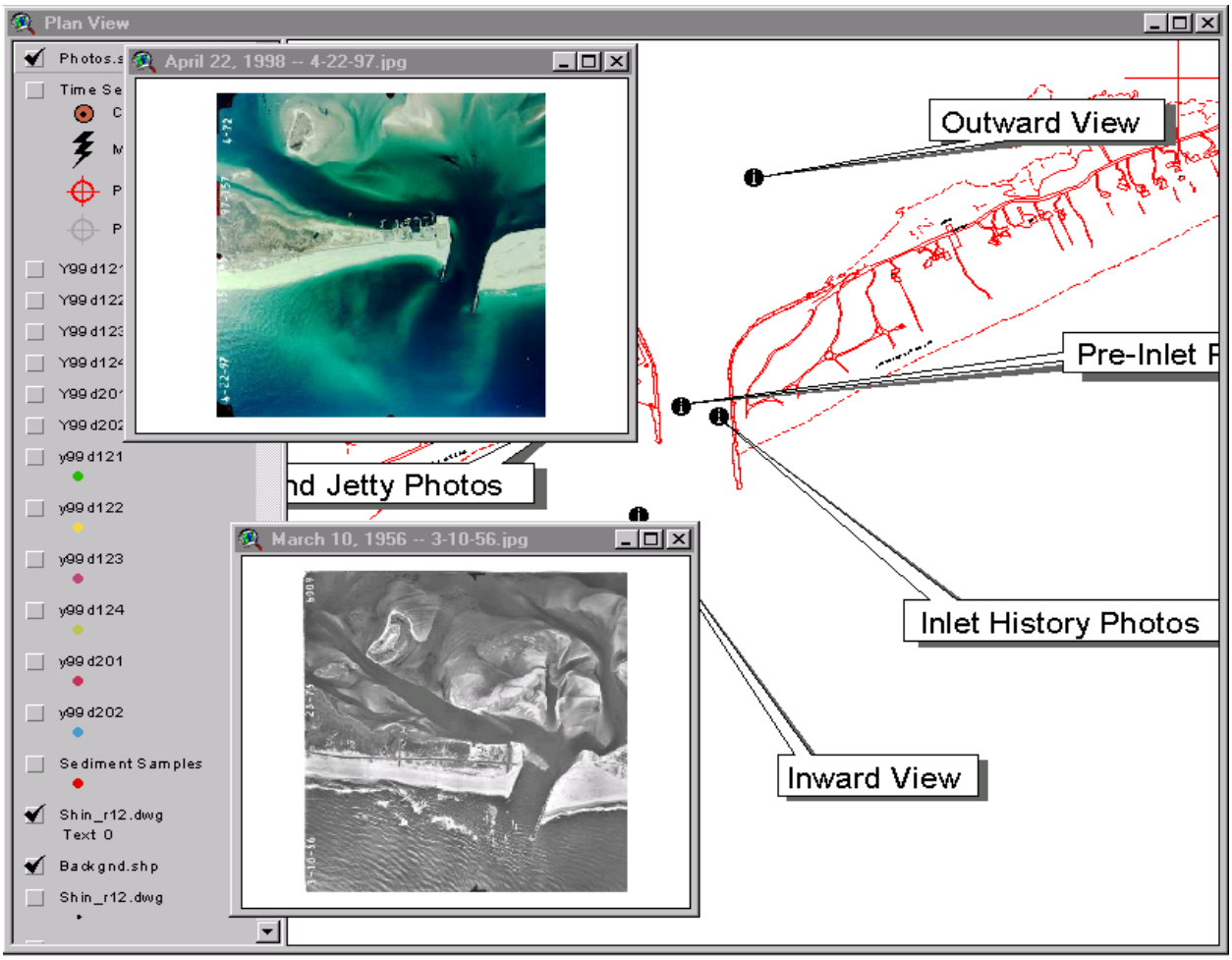

Figure 4. Shinnecock Inlet GIS project utilizing HyPAS tools for displaying photographs

The user can click to create a location for time-series data and import the data for that location. Later the user can choose that location and HyPAS will display all the data types, which have been imported.

HyPAS will plot the data on an *x,y* plane using the plot and axis information given by the user. HyPAS automatically exaggerates the *y* axis to fit an 8.5 x 11 landscape plot. Figure 5 shows a time-series plot of wind speed information.

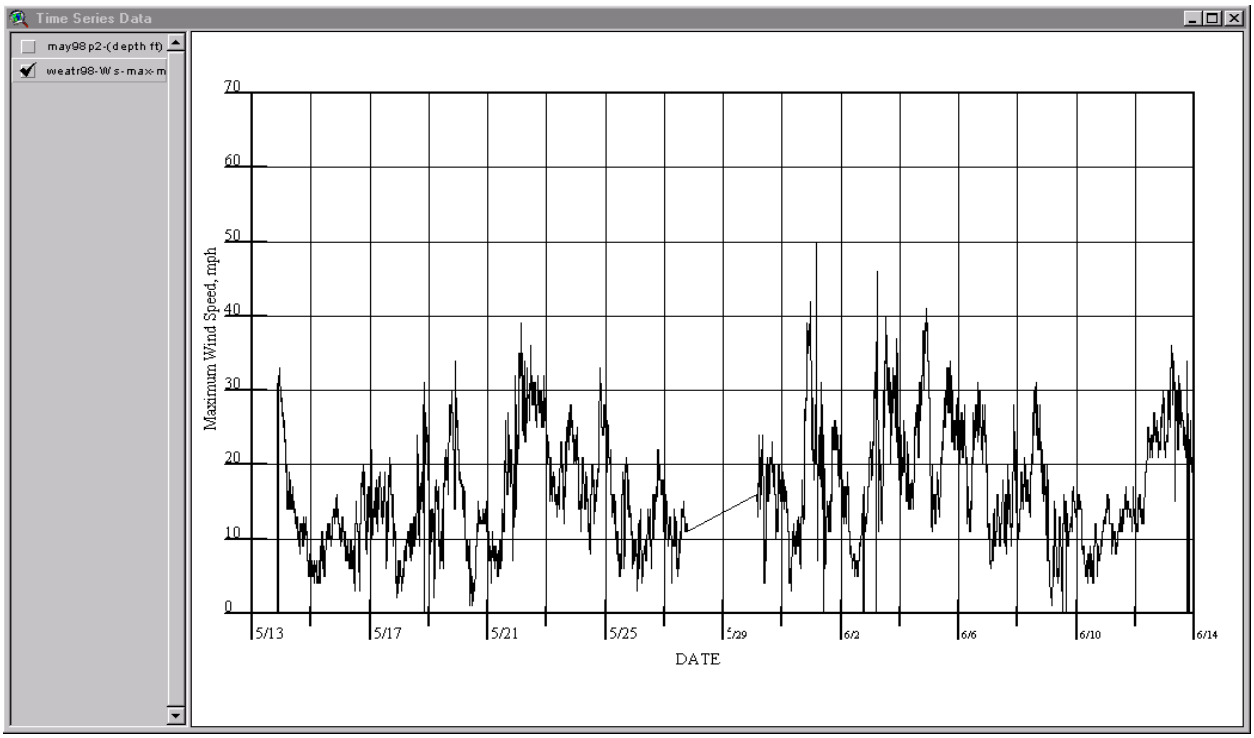

Figure 5. Maximum wind speed time-series data plot

SEDIMENT SAMPLE ANALYSIS TOOLBOX: HyPAS provides capabilities for analyzing sediment samples and similar data. The user can plot cumulative frequency weight percent or frequency weight percent histograms. HyPAS keeps these plots linked with the data in plan view as well as tabular view.

The user can then select certain samples in the plot and see those specific samples highlighted in plan and tabular views. This linkage works in all three views such that any selections including tabular queries are reflected in the other two views. The user can select samples in any of the windows, and the other two windows will show the selection.

Figure 6 shows the linkage between a frequency weight histogram plot with the plan view and tabular data view. Note the selected (red colored) samples in all three views.

PLOTTING GRAIN SIZE DISTRIBUTION: HyPAS provides the capability of plotting grain-size distribution for sediment sample data. The user can plot cumulative frequency weight or frequency weight percent histograms. HyPAS can plot all samples selected or calculate a composite for the selected samples. The user has the option of sorting the tabular data before making a selection of samples for display in the plotting window.

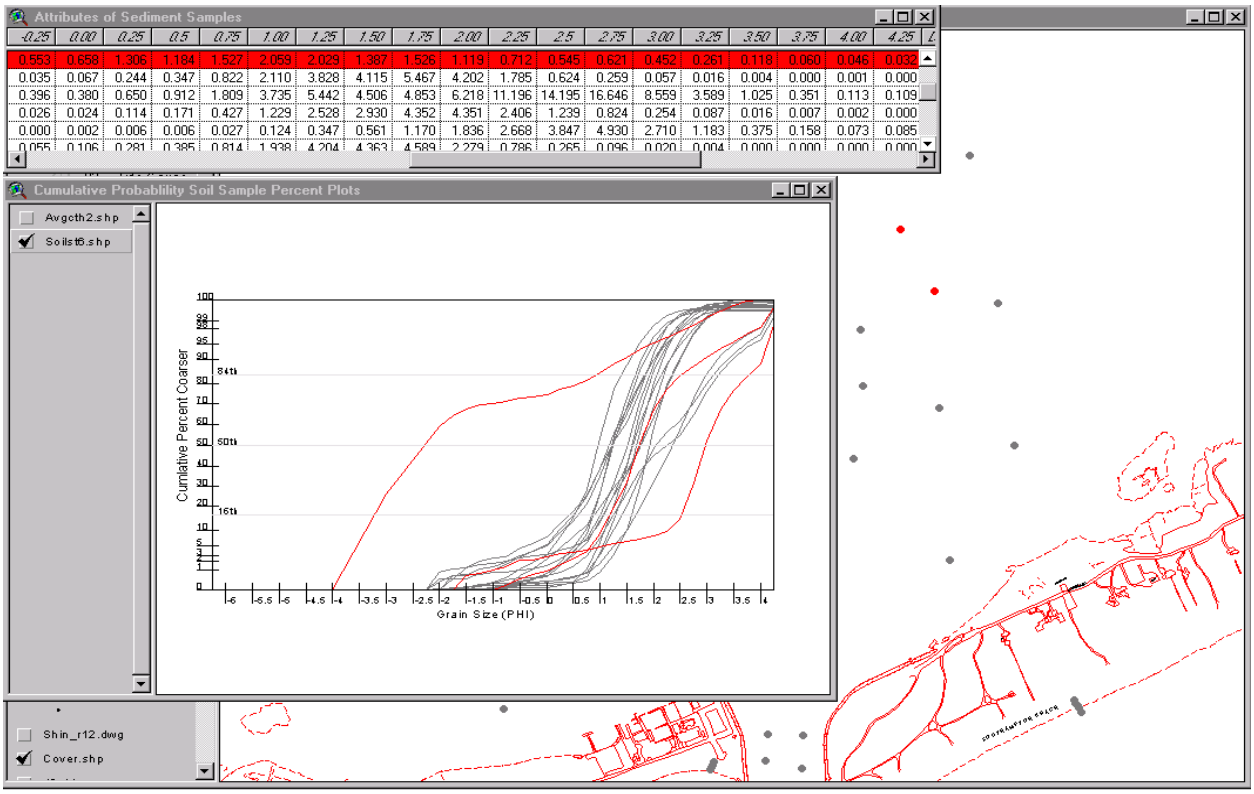

Figure 6. View showing link between distribution plots and plan view data

Once sediment samples are imported, the user must select the samples desired for a grain-size distribution plot before selecting the Sediment Sample Tool. The option to plot the cumulative frequency weight percents, the frequency weight percent histogram, or a composite sample plot is provided. HyPAS then generates the distribution plot. Figure 7 shows frequency weight percent histograms with a composite histogram from a subset of sediment samples collected from the Shinnecock Inlet. A cumulative frequency weight percent plot of the same sample is also shown. The thicker line delineates the composite sample. Various statistical parameters describing this composite sample are stored to a table. These statistics include the median, other percentiles, the Fill Factor (R_A), and the Renourishment Factors (R_J). Different composites can then be easily compared. See Hands and Chu (1986), *ftp://redarrow.cerc.wes.army.mil/ftp/pub/pub/pdf/cetnii-15.pdf*, for a discussion of the R_A and R_J. The broader aspects of coastal sediments, including their composition and fall velocity, are discussed by King (1999), *http://www.usace.army.mil/inet/usace-docs/eng-circulars/ec1110-2-292/c-1.pdf*.

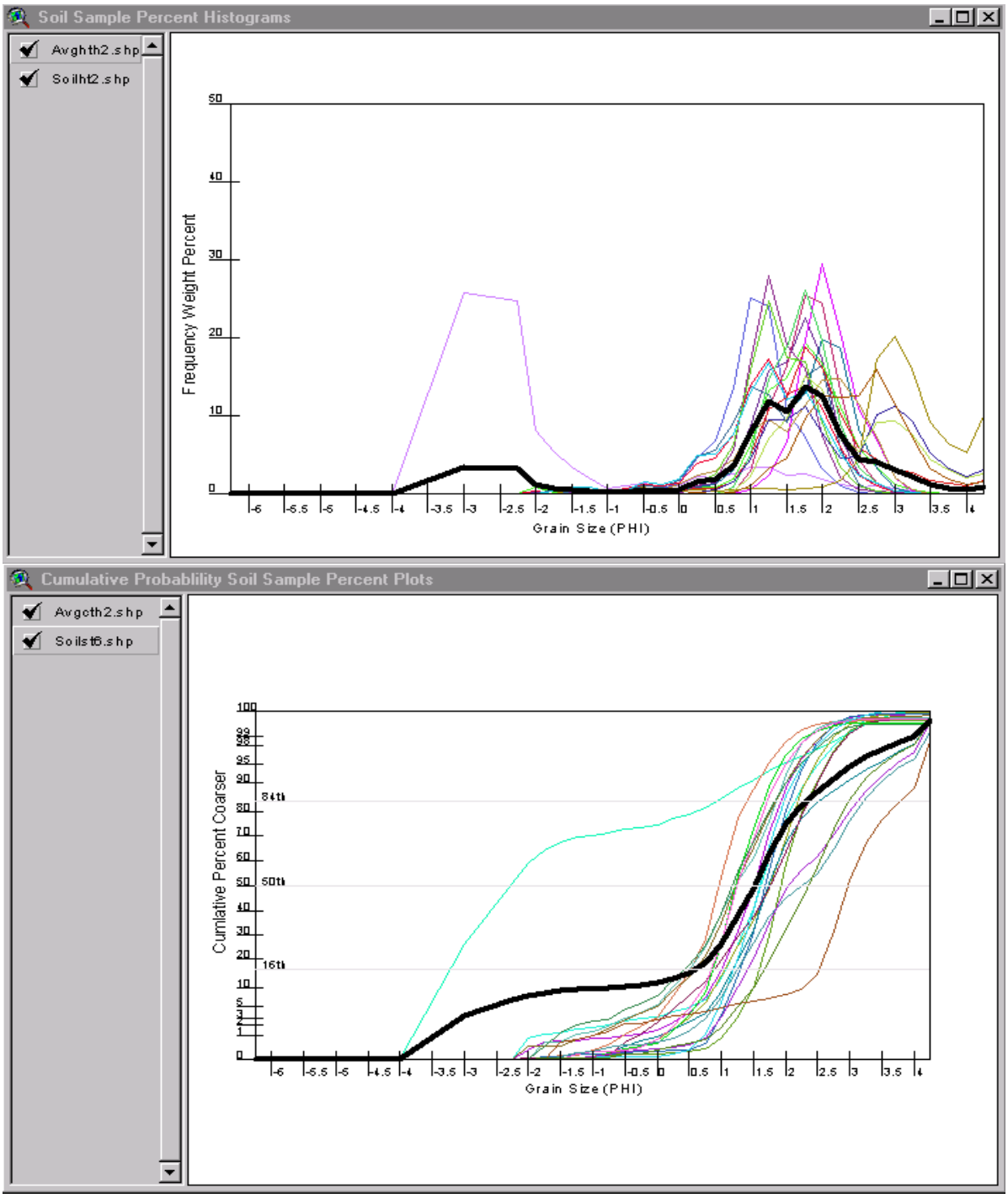

Figure 7. Example of a series of sediment samples and composite sample. The first plot displays the frequency weight percent histograms, and the second plot displays the cumulative weight percent

EXTENSION INFORMATION: HyPAS is an extension to ArcView 3.1. It enhances or automates some features already present in ArcView's Graphical User Interface (GUI), and it extends the current capabilities of ArcView 3.1. All of functionality of ArcView 3.1 and Spatial Analyst extension is still available to the user along with HyPAS capabilities. This affords access to the power of ArcView GIS and HyPAS. The user could create a hillshade of bathymetry in ArcView and Spatial Analyst; then overlay vector magnitude and direction plot using HyPAS to produce even more useful output. (Figures 8 and 9) SHOALS (*http://shoals.sam.usace.army.mil*) data have also been imported to create contoured plan view plots and hillshade applications.

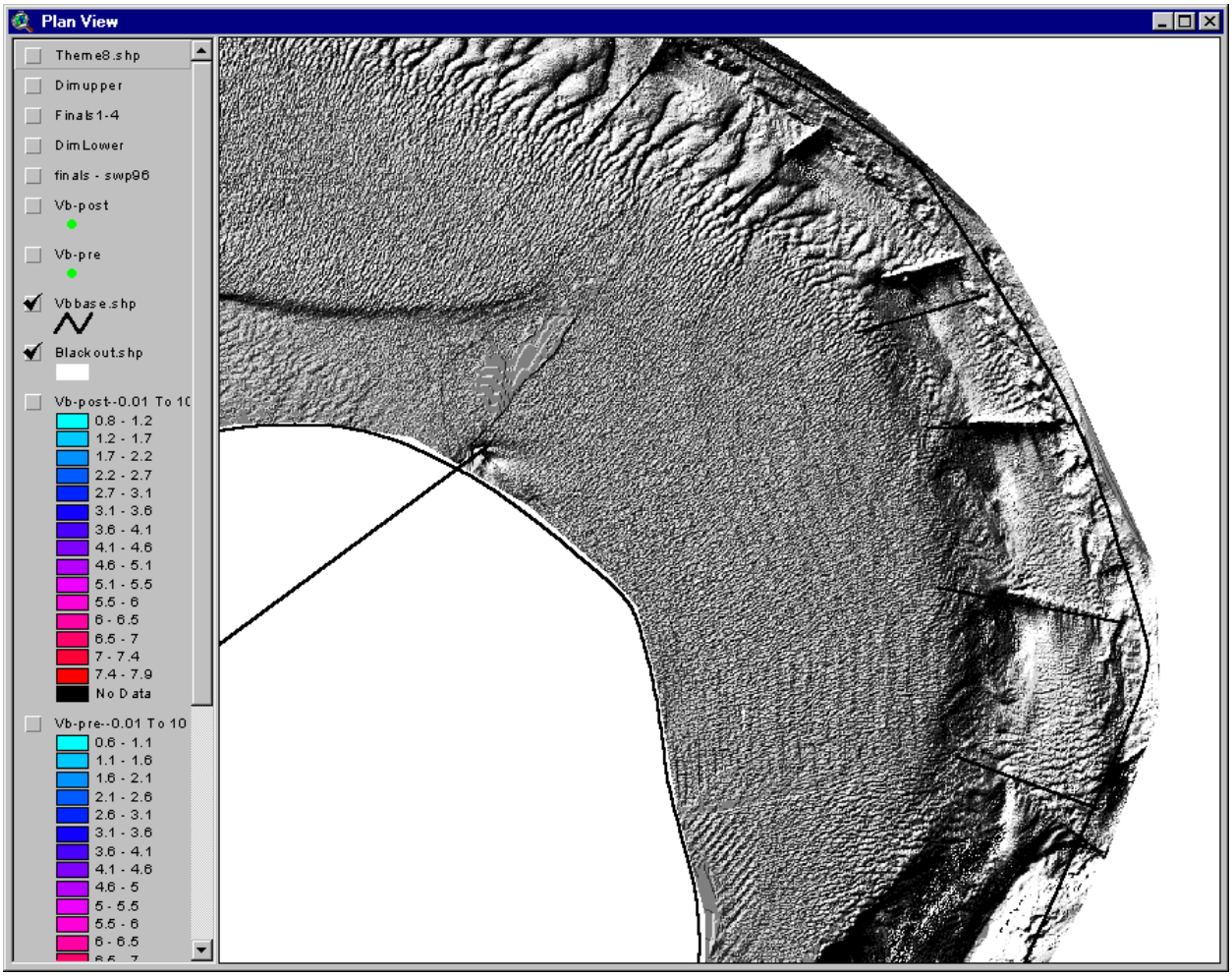

Figure 8. Hillshade of high resolution multi-beam bathymetry, Victoria Bend, Mississippi River

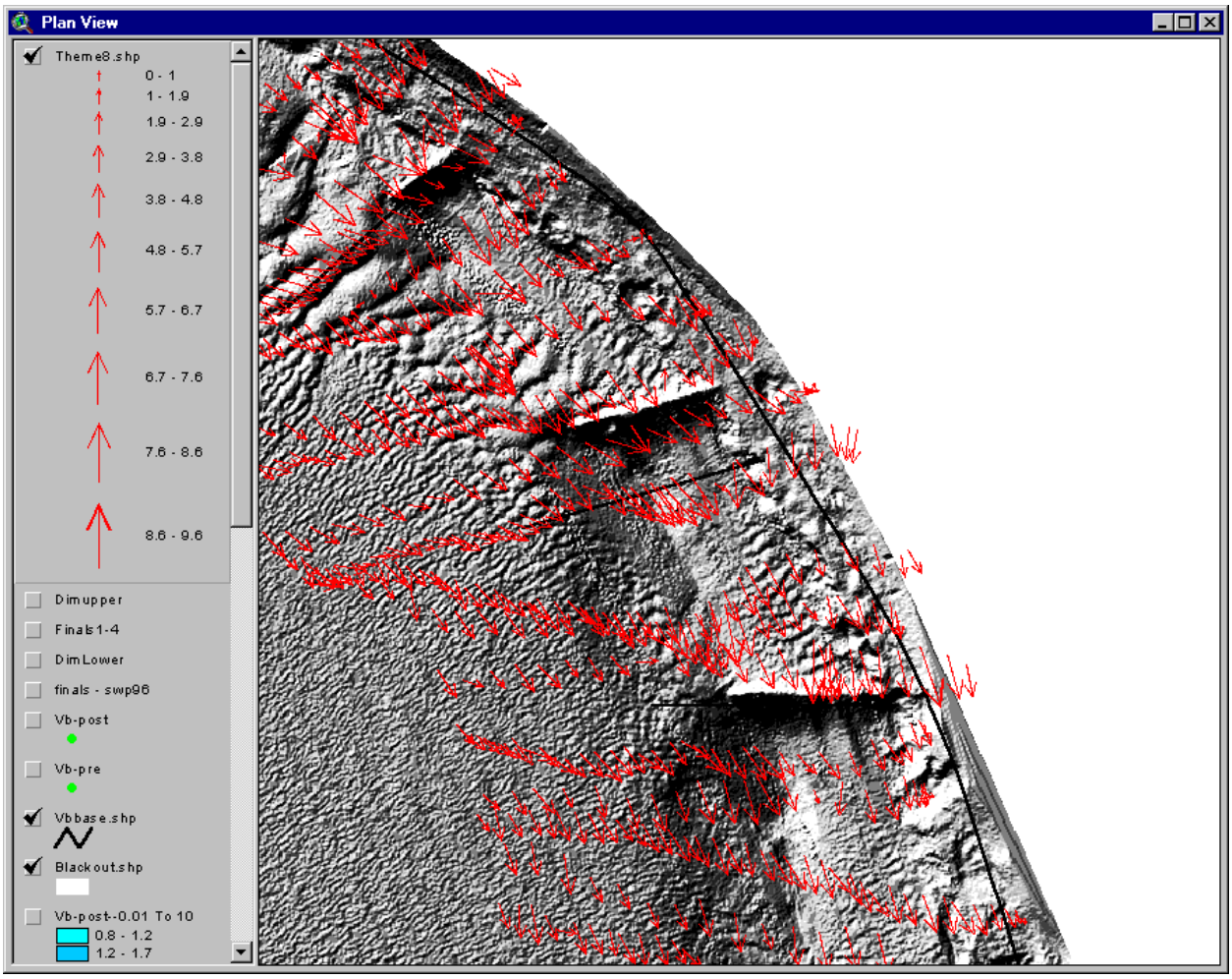

Figure 9. Bathymetric hillshade with vector magnitude and direction overlaid, Victoria Bend, Mississippi River

ADDITIONAL INFORMATION: For further information, contact Mr. Thad C. Pratt, U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (Voice: 601-634-2959, e-mail: *prattt@wes.army.mil*) or Mr. Daryl S. Cook, Digital Information and Mapping Company (DIMCO, Inc.) (Voice: 601-634-4086, e-mail: *cookd@dimco.net*).

For information about the Coastal Inlets Research Program, please contact Dr. Nicholas C. Kraus (Voice: 601-634-2016, e-mail: *krausn@wes.army.mil)*. Any mention of a commercial product does not constitute an endorsement by the Federal Government. This CETN should be cited as follows:

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Pratt, T. C., and Cook, D. S. (In press). "HyPAS user's manual: A hydraulic processes analysis system," U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.